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Original Article

A COMPUTATIONAL FLUID DYNAMIC ANALYSIS OF THERMOSTAT VALVE (USING CMM AND MAKING PROTOTYPE THROUGH RPT)

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ABSTRACT

Technical method for computer-aided reverse engineering, illustrated by a real working component of an aluminum-alloy thermostat valve from a MARUTHI ALTO vehicle. In this work involved reconstruction of component dimensions using 3D scanning or coordinate measuring machine (CMM) and casting process optimization using simulation software, and prototype to be fabricated and tooling using rapid prototyping systems. Dimensions are measured using CMM. Model was created with help of dimensions measured and by slight modified for the improvement in temperature control from Computer Aided Design (CAD) data. After this modified component model convert into STL file then prototype model was created by Rapid prototyping and Tooling (RPT) in 3D viper SLA system. Flow analysis is done with a Computational Fluid Dynamics (CFD) simulation which helps to find out the temperature distribution to control the engine temperature. The outlet temperature of the modified model 300k is less than that of the existing model 325k.

KEYWORDS: CFD, 3D Scan, CMM & CAD Data

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INTRODUCTION

Reverse engineering has its beginning in the analysis of hardware for public usage or military and industry advantage. However, this process in itself is not concerned with creating a copy or changing the artifact in some way; it is only an analysis in order to deduce design features from products with little or no additional knowledge about the procedures involved in their original production. In some cases, the goal of the reverse engineering process can simply be a re-design of legacy systems.

As Computer aided design (CAD) has become getting the most importance of commercial equipment's and viable method to create a 3D virtual model of an existing physical part for use in 3D-CAD, CAM &CAE or other software. The reverse-engineering process involves scaling the dimensions of an object and then re-designs it as a 3D model. Some physical methods like CMMs, laser scanners, structured light digitizers, or Industrial computed tomography scanning then object can be measured using this. The measured data alone, usually represented as a point cloud, lacks topological information and is therefore often processed and modelled into a more usable format such as a triangular-faced mesh then create a 3D solid model using Pro – E, Solid works, CATIA or a CAD model.

Reverse Engineering in Traditional Manufacturing Industries

Reverse engineering is generally a lawful way to acquire know-how about manufactured products and traditional production industries. This process may be undertaken for many purposes for all industries. We concentrate in this Part on reverse engineering be taken for the purpose of making a competing and complicated product because this is the most common and most economically significant reason to reverse engineer in this industrial context. We know the process of traditional manufacturing and argue that legal rules favoring of this manufactured products have been economically sound because an innovator is nevertheless protected in two ways: by the costliness of reverse engineering and by lead time due to difficulties ofreverse engineering. If technological advances transform reverse engineering so that it becomes a very cheap and rapid way to make a Competing product, innovators may not be able to recoup their R&D expenses, and hence some regulation may be justified.

An Economic Perspective on Reverse Engineering

The number of factor consider economic effects of reverse engineering and including the purpose for which reverse engineering is undertaken, the industrial context within which such acts occur, the costs and time required to engage in reverse engineering, the amount of lead-time the innovator has before competitive entry occurs, whether second comers decide to reverse engineer or to license the innovation, and what the reverse engineer does with the information discerned in the reverse engineering process. In this subsection, we concentrate on the economic effects of reverse engineering undertaken for the purpose of developing a similar competing product or animproved product. In the traditional manufacturing context, this has been the most common and economically significant purpose for reverse engineering.

Experimental Procedure

In this case, I have selected the Thermostat component which is aluminium based casting was selected. By adopting the reverse engineering concept, the considered component is to be made by rapid prototyping concept such as Fused deposition modelling. Since the component having complex geometries it cannot be duplicated as it is. So by using Coordinate measuring machine (CMM) the dimensions of component is taken.

Coordinate Measuring Machine

This Coordinate measuring machine available in kalasalingam University, Krishnan koil. It is having the 2.5 um high precision (Swiss made), Pneumatic controller – 4 bar systems.

Figure 1: Coordinate Measuring Machine

The values are took using CMM and the following dimensions are below

Table 1: Thermostat Valve Component Dimensions

Parameters	Dimensions
Cylindricity	0.148
Conical surface; Inclination	38.11.37
Height	30mm
Polar coordinates; U V	313.491 0.12.03
Squareness XY Reference length	15.69
Parallelism; ZX XZ	0.110 0.140

The above dimensions are taken by using CMM. The component is modelled by using Pro-E software. This software is used because of the ease of modelling and able to convert part file in to STL file. The Rapid prototype machine can able to make a product itself while the modelled component is in STL format.

Modelling Procedure

Using the Pro-E software, the component is modelled in Part Module. Then Part file is converted to STL File(steriolithography). The modelled component is attached with this

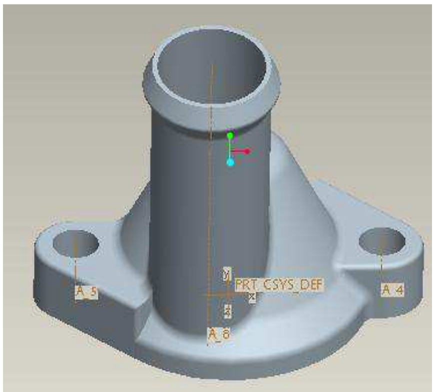

Figure 2: Existing Component Default View

The Above component is modeled by taking the dimension taken using CMM After the component is modeled in pro-e part module, this part file is converted to STL file which will compatible with Rapid prototype machine.

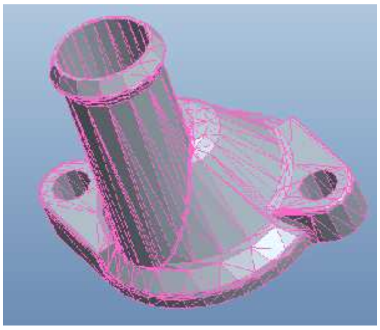

Figure 3: Convert STL Format

The stl file is to be transferred from Pro-E to Fused deposition machine so that accurate replica of the component is made without any hurdles. The raw material of component to be made is ABS. The component to be obtained is finally modeled in ANSYS. By applying loads and Boundary conditions, the deformation is to be noted. If the deformation is within limit, the component to be made by reversed engineering concept will be successful.

Drafting of Component

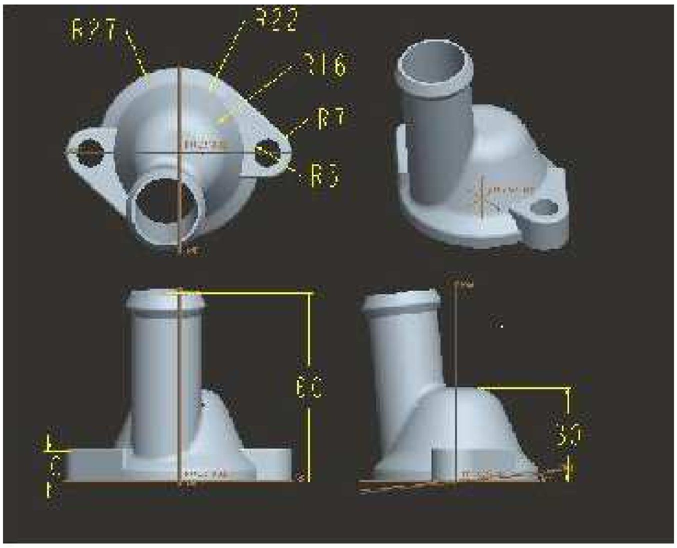

Figure 4: Modified Component Model

Rapid Prototyping

Rapid manufacturing techniques enable complex shaped parts to be produced directly from specific tooling or machining of a computer model without conventional part. Totally it is having two routes for fabricating the part: First one is direct route in which the part is produced in plastic, resin or paper directly from the CAD data using a suitable rapid prototyping (RP) system, and second is indirect route in which the RP parts can be used as masters for fabricating the tooling through a suitable rapid tooling (RT) method using epoxy, polyurethane or silicone rubber. The parts produced by direct or indirect route in resin, paper, plastic or wax material can be used as a pattern or mould for sand casting or investment casting as appropriate. This enables producing near net shape metal parts, which can be machined to final dimension and tolerances. The Computer Numerical Control (CNC) program required for the machining can also be generated directly from the CAD model or any 3D model software of the part using CAM software.

Viper SLA System Process

This is one of several techniques followed from rapid prototyping, the RP machines are making the component as per our feeding to the system build one layer at a time from polymers, paper or powdered metal. The machines are autonomous, for this needing no human intervention during layer construction of given part component. There are four major rapid prototyping techniques, each with unique strengths: selective liquid solidification, semi-liquid deposition, sheet laminating and powder binding 5. The Steriolithography (SLA) developed by 3D Systems, Inc. uses photosensitive resins cured with an ultraviolet laser. The SLA Quick Cast is a variation of the Steriolithography process giving a hollow honeycomb structure of polymeric material.

We use the Viper SLA system to produce parts in high resolution enabling very fine detail to be replicated. The Viper SLA prototyping system can build in extremely fine layers, 0.05mm and the fine point laser beam can build sections down as small as 0.3mm

Figure 5: Viper SLA System with RP Model

This Viper SLA system with RP model process is conducted at PSG tech Coimbatore. There are three types of RPT machine is there. This model has been produced by 3D Viper SLA system. It is one of the rapid prototyping and tooling machine. This model made on ABS plastic material.

Figure 6: Prototype Model Made by ABS

The design is modified geometricaly, from the previously existing design for achiving a better performance. The CFD analysis on the thermostat valvve is carried out and temprature distribution are determined at inlet and outlet section of the valve.

Computational Fluid Dynamics

First CFD Analysis was Analysed for Existing Model

Existing Model-Geometry modeler (Fluid Domain)

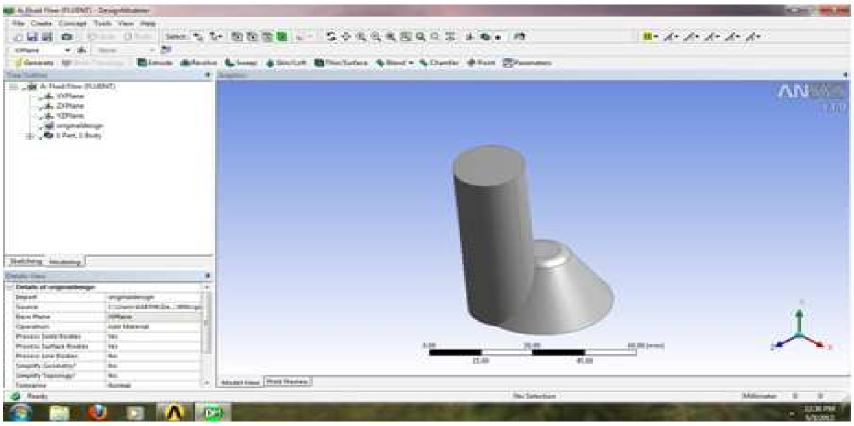

Figure 7: Existing Model Geometry Modeler (Fluid Domain)

From the given exiting component model has been created using Pro/E then convert into geometry modeler fluid domain.

Pre Processing

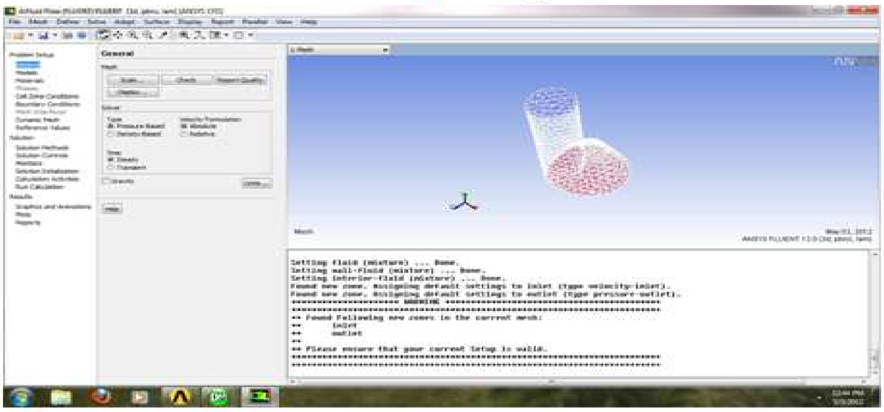

Figure 8: pre processing

From this second step where the input and output conditions are fixed. Top

Cylindrical portion is inlet and bottom circular hole is outlet conditions.

Comparison between the Temperature distributions;

Exiting component model

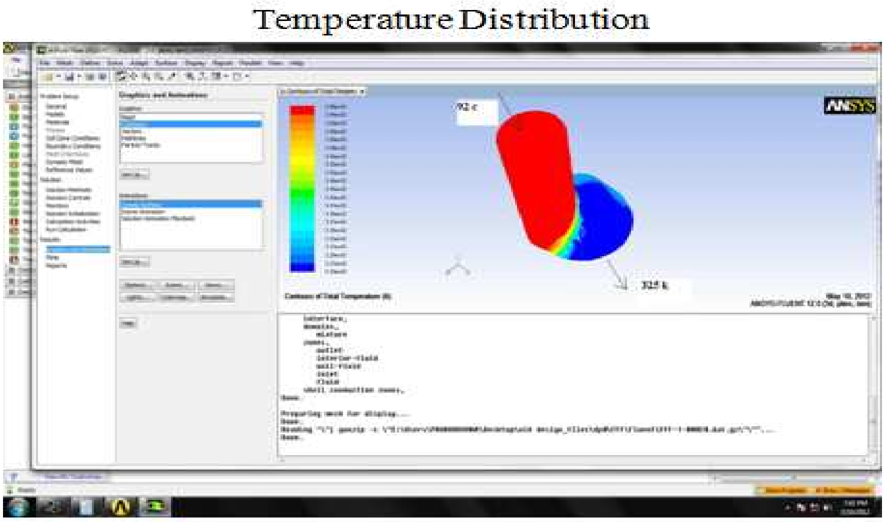

Figure 9: Temperature Distribution

The CFD analysis on the thermostat valve is carried out and temperature distribution are determined at inlet and outlet section of the valve.

The valve opened at 92^0 c.

Engine input temp. 325 k

Modified component model;

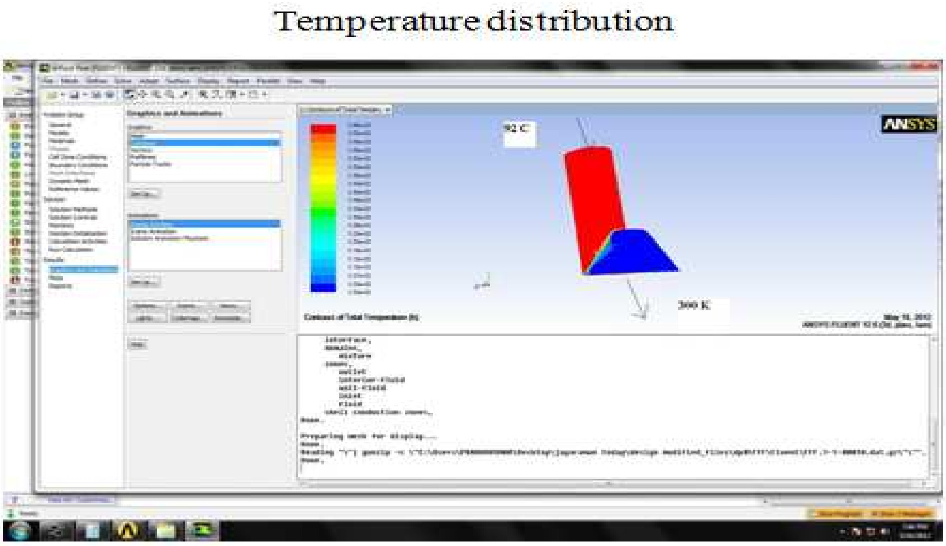

Figure 10: Comparison of Temperature Distribution using CFD

The valve opened at 92^0 c. Engine input temp. 300 k

Modified model-Geometry modeler (Fluid Domain)

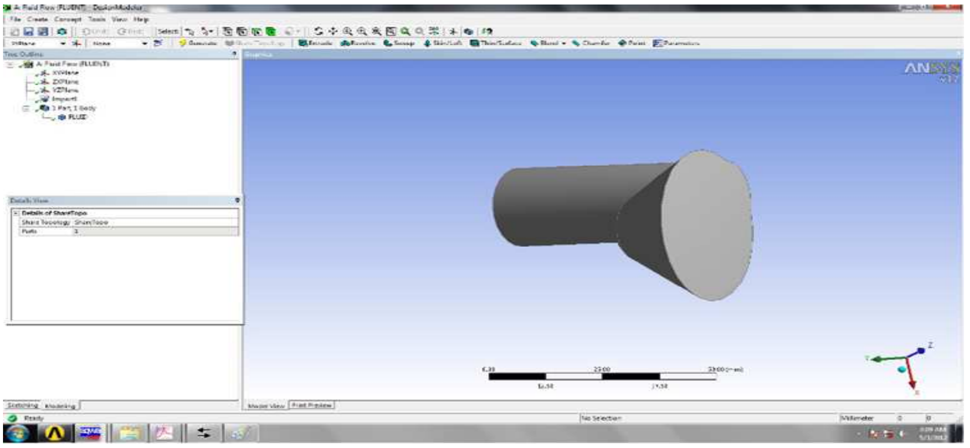

Figure 11: Modified Model Geometry Modeler (Fluid Domain)

From the given modified component model has been created using Pro/E then convert into geometry modeler fluid domain.

Meshing the geometry

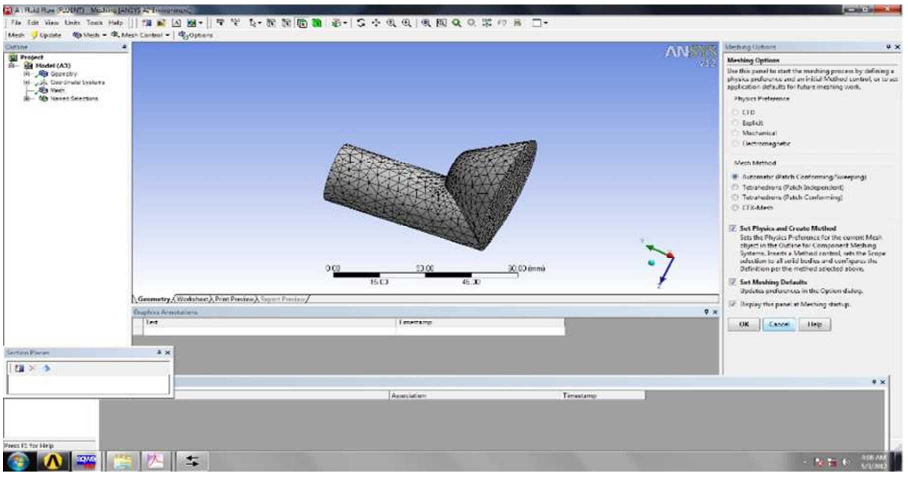

Figure 12: Meshing the Geometry

Given geometry model has been meshed from the fluid domain using finite element analysis.

Pre- processing

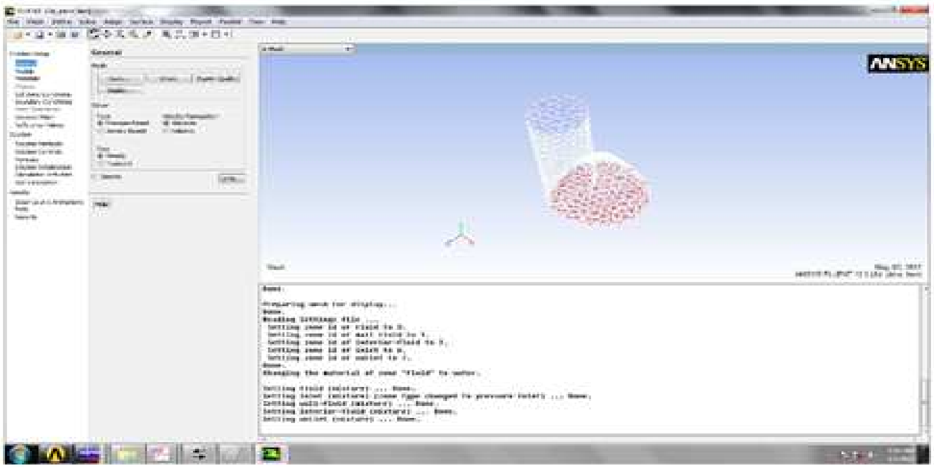

Figure 13: Pre Processing

From this second step where the input and output conditions are fixed. Top cylindrical portion is inlet and bottom circular hole is outlet conditions.

Outlet Flow conditions

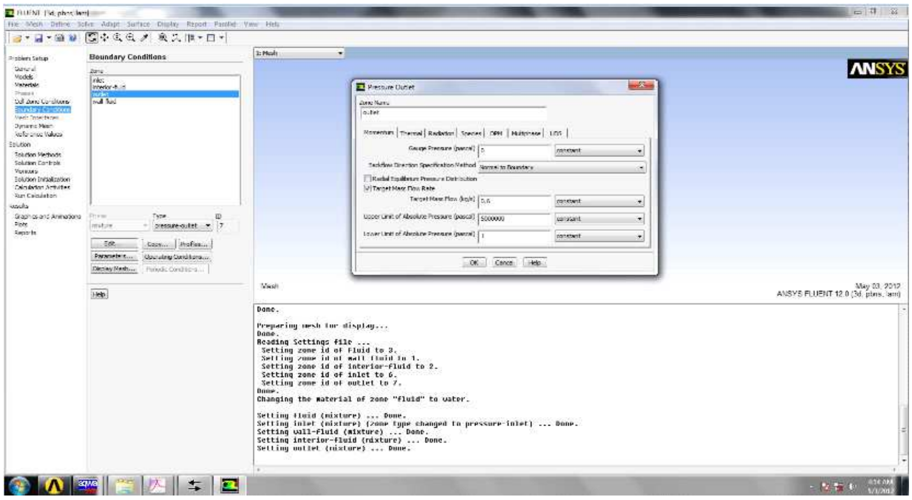

Figure 14: Outlet Flow Conditions

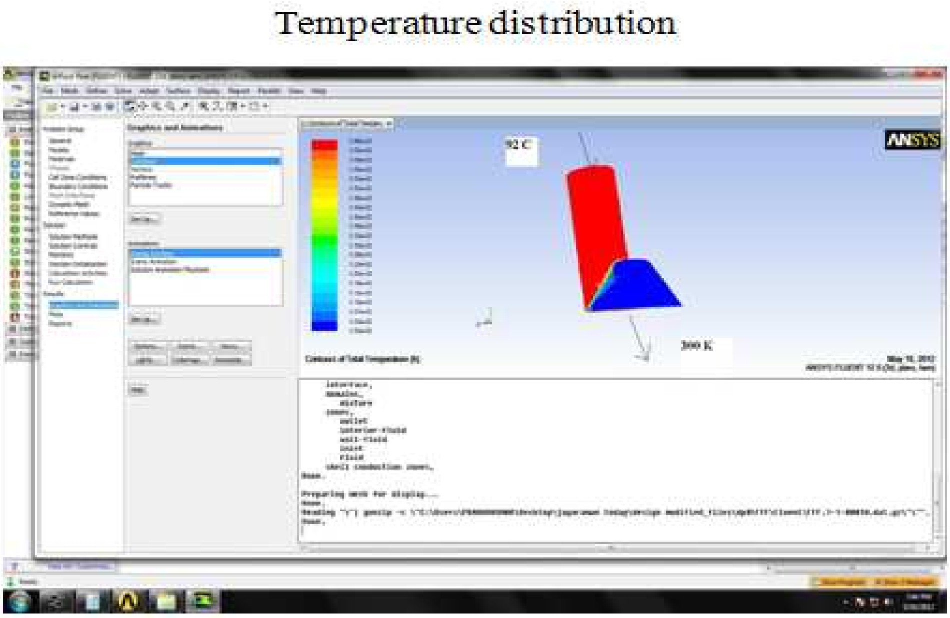

Figure 15: Temperature Distribution

The CFD analysis on the thermostat valve is carried out and temperature distribution are determined at inlet and outlet section of the valve. Finally the temperature to inlet condition for engine is reduced from existing model.

CONCLUSIONS

There is an increasing interest in reverse engineering of parts whose drawings (geometric, material and manufacturing details) are not available, especially those required one-off or in a few numbers, such broken and worn-out parts to be replacement for this process. From that dimensions used to developed the component model for existing and modified with use of Pro/E modeling software. It is the facilitated by the availability of technology rapid tool manufacturing using 3D viper SLA system given thermostat valve prototype model has been produced.

The CFD analysis on the thermostat valve is carried out and the temperature distribution determined at outlet section of the valve. The outlet temperature92^0 C reduced through our modified design from existing 325 K to 300 K.

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